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Title: Optical Probes for Hydrotests

Author(s): Primas, Lori Ellen
Sullivan, Gregg Kent
Pickrell, Mark Manley

Intended for: Background information for visit to Timbercon

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Optical Probes for Hydrotests Visit with Timbercon

Lori Primas, Gregg Sullivan, Mark Pickrell

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Purpose of our visit

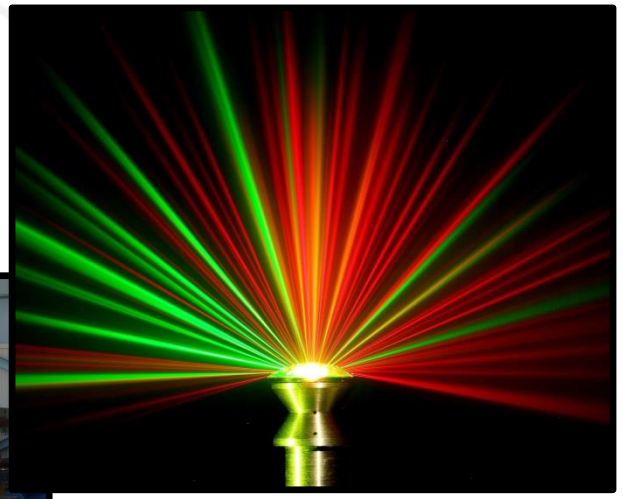
- Work with Timbercon to help us improve performance of optical probes for hydrotests.

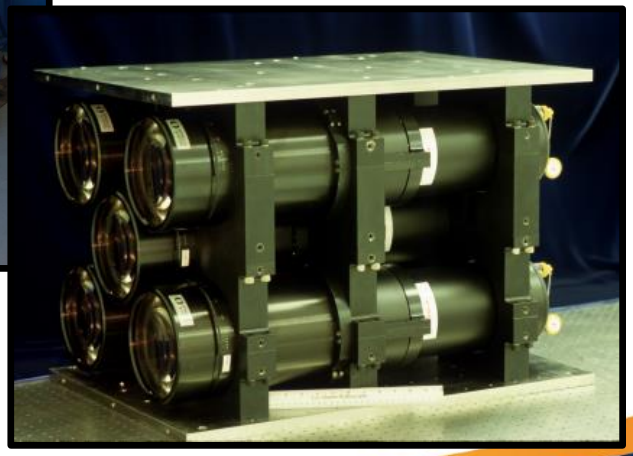
- Discussion:
  - What is a hydrotest?
  - Description of optical hydrotests
  - Current design of optical probe
  - What is need to improve performance of optical probe?

Hydrotests

- Hydrotests, also know as hydrodynamic experiments, are:
  - Performed at a firing sites such as DARHT or R306 (usually contained in 6 foot vessels)
  - Consist of weapons-like assemblies, using surrogate materials
  - Modified to include integrated diagnostics
  - Data from diagnostics is used by our modelers to improve their codes and test weapon performance

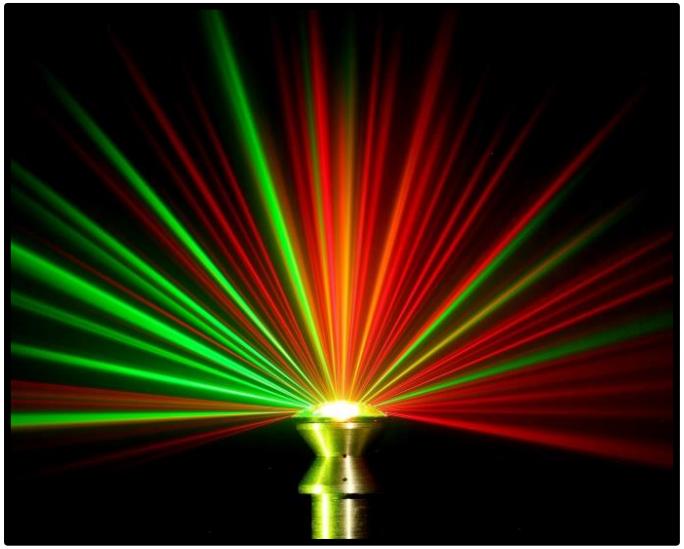
Hydrotests at DARHT



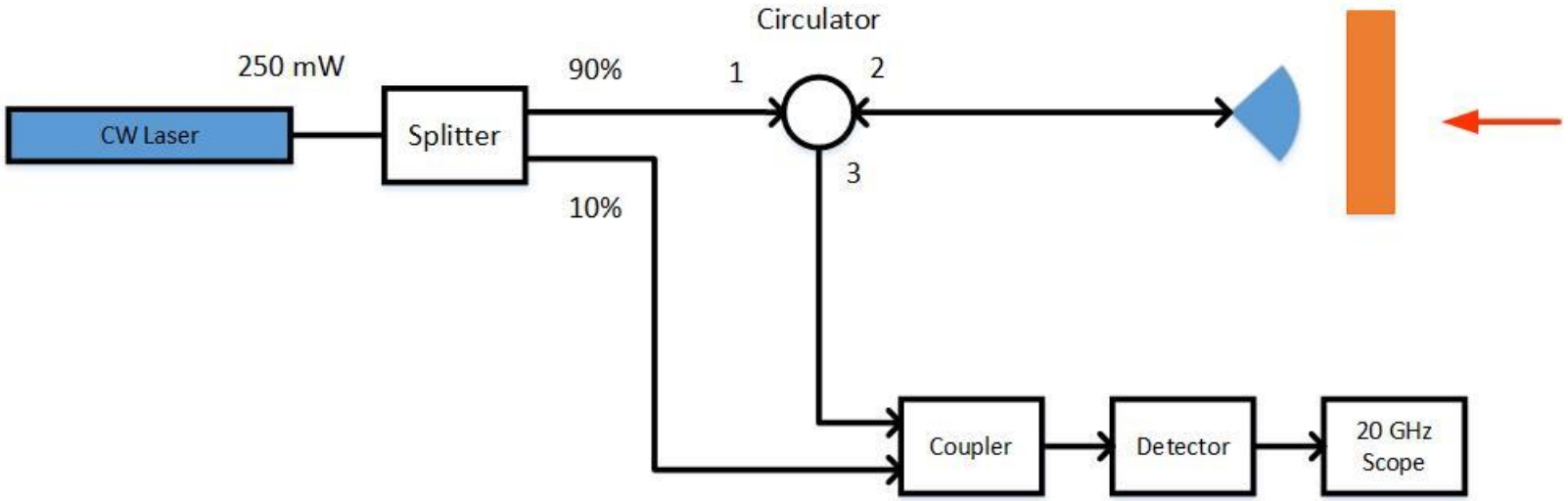


Optical Hydrotests

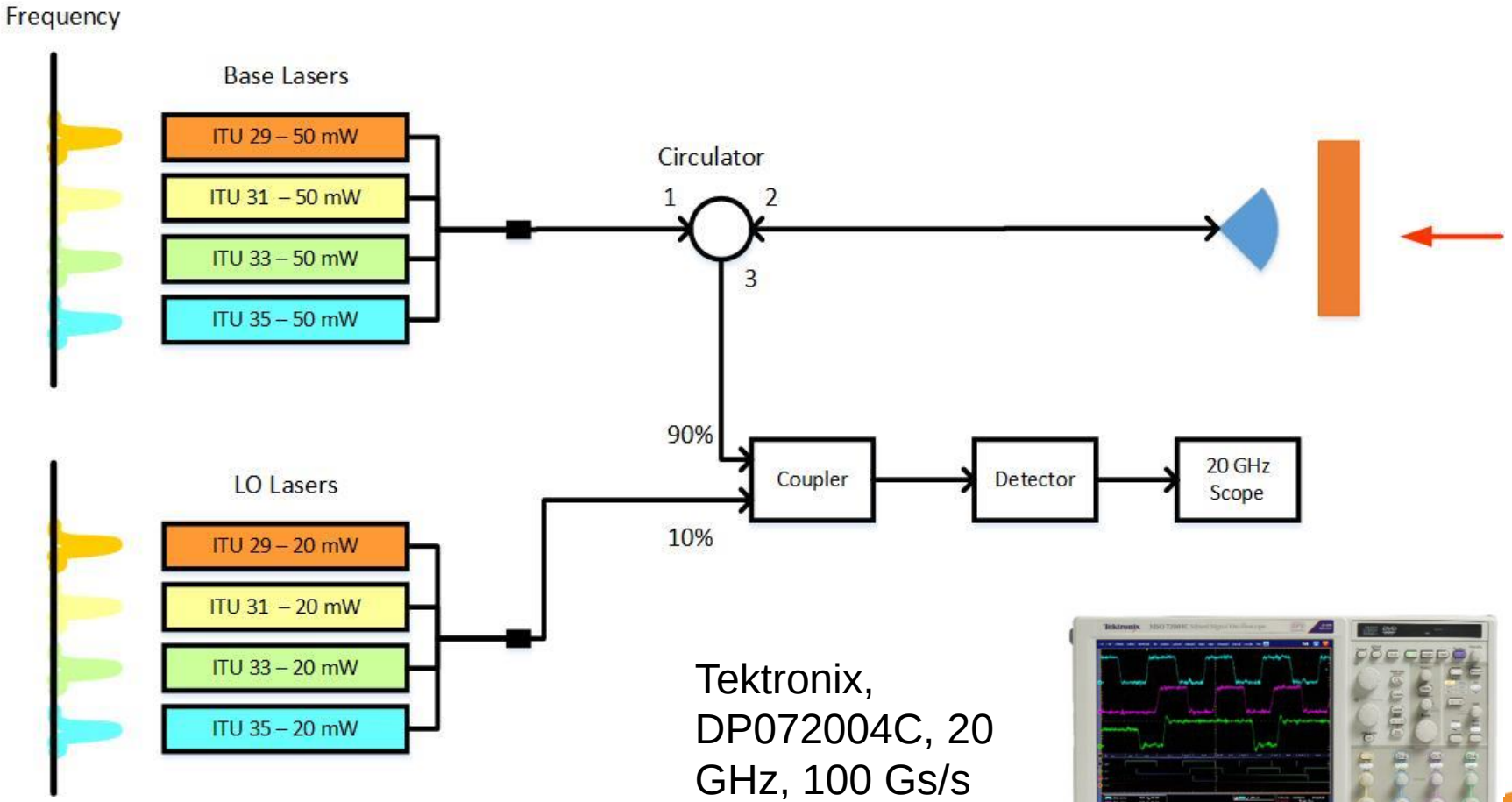
- Unique capability at LANL
- Used to collect early time implosion data from initial motion to probe impact
- Requires an optical probe with hundreds of beams, coupled to an data collection system (MPDV)



PDV – Photon Doppler Velocimetry

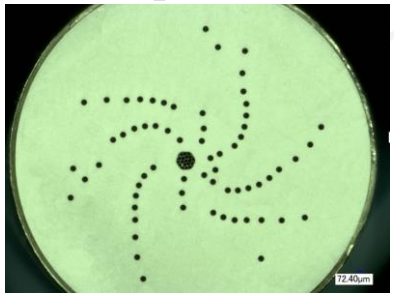


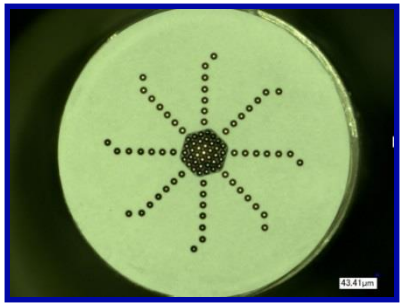
MPDV – Multiplexed Photon Doppler Velocimetry



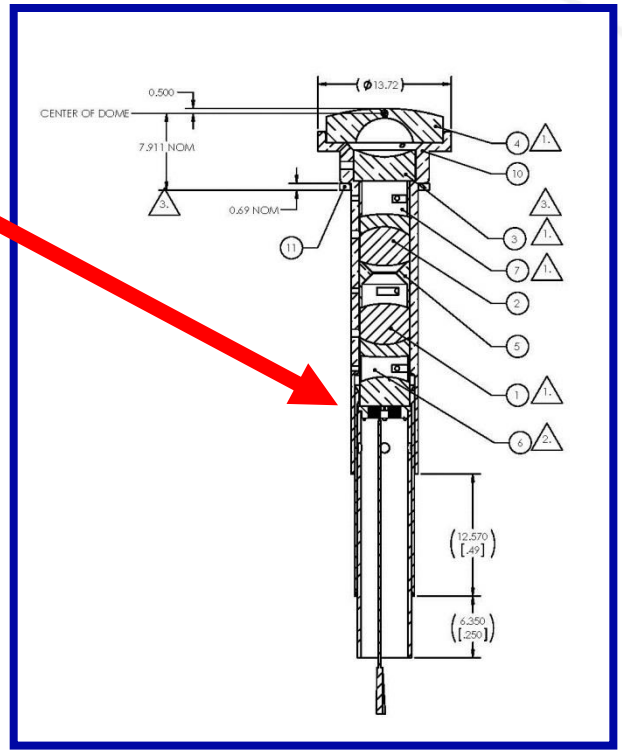
Tektronix, DP072004C, 20 GHz, 100 Gs/s

Optical Probe Design



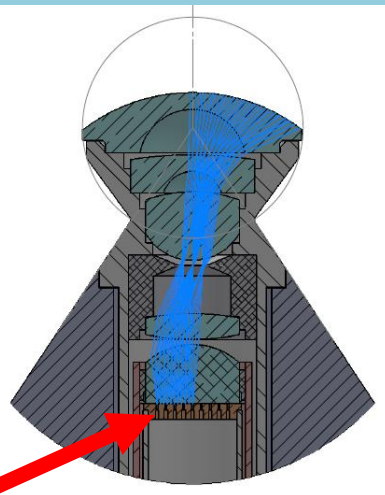


Beam distribution and density defined by mask



Minimize lens diameter to increase late time data collection, but this decreases optical quality

Beam collimation (size & shape) defined by lens system

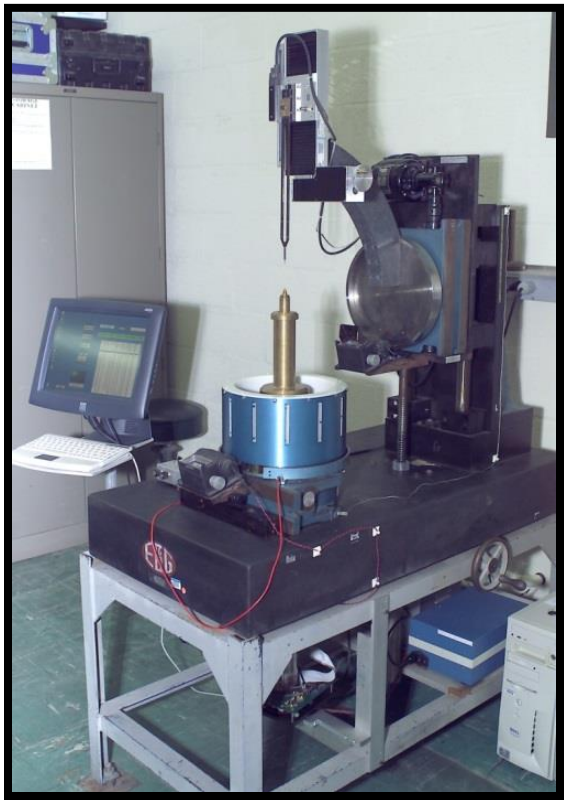


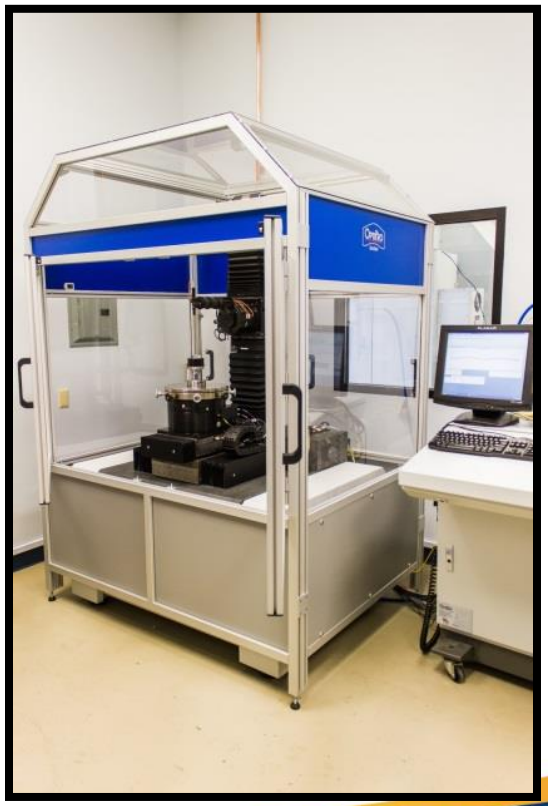
Index matching fluid between fibers and first lens surface

Single mode fibers coupled to mask

Optical Probe Beam Position

Currently measure beam position to within +/- 0.002” at 3 radii, will be able to automate measurement beam location to within +/- 10 um at +10 radii with CMM like machine

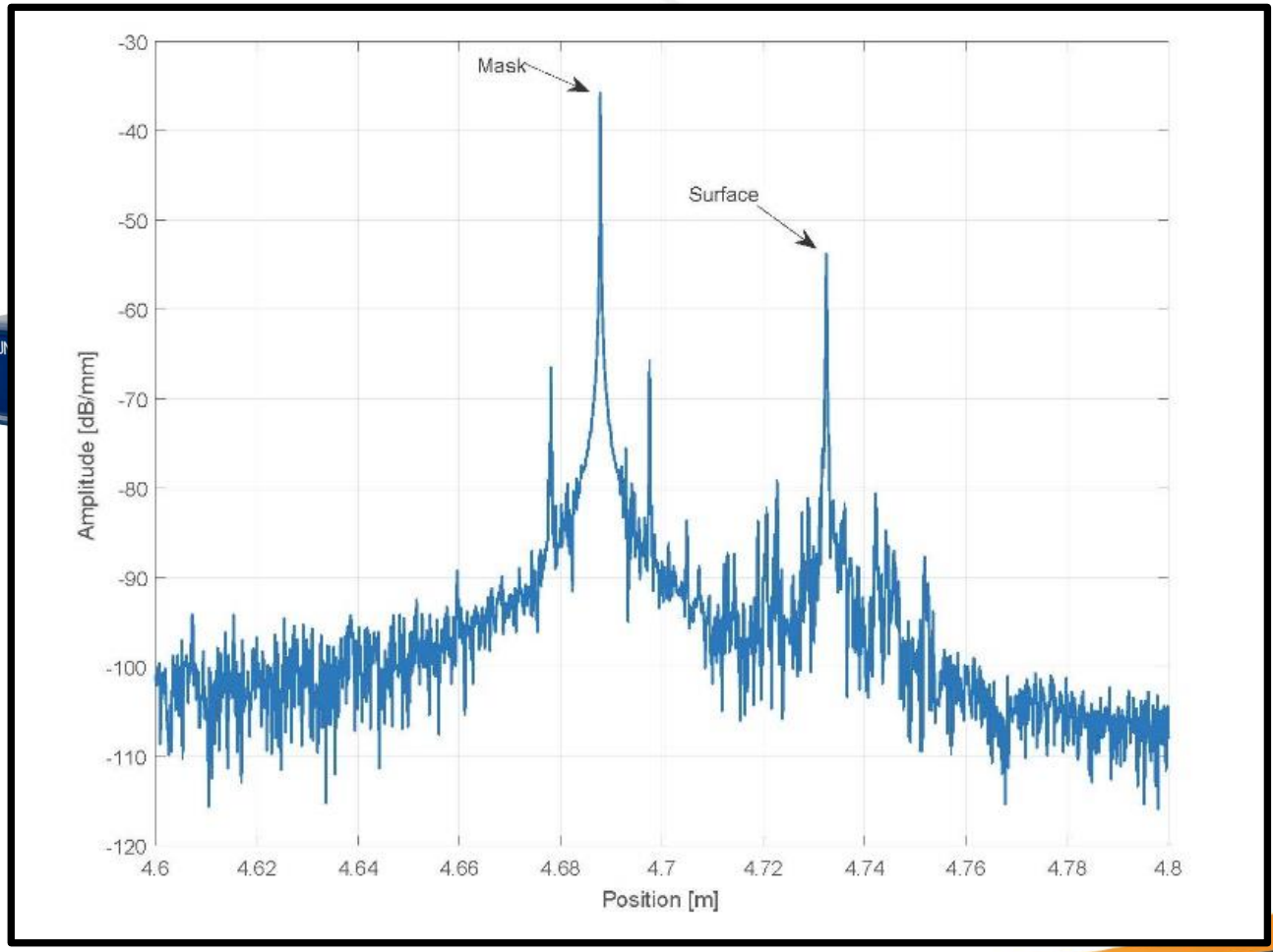




Optical Probe Back Reflection

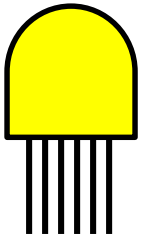
LUNA OBR
Optical Back Reflection
10 micron spatial resolution

Back reflection at mask-fiber interface is larger than the back reflection at the dynamic surface

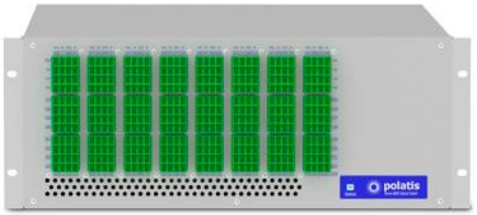


Current Configuration

Fiber coupled optical probe (~300 beams)



Polatis Optical Switch 192 X 192



MPDV Gen 2 – 128 channels

Maximize Ad/

- Measure the ratio of back reflection from the fiber-first lens surface interface (A_s) and the dynamic surface (A_d) $Q = (A_d) / (A_s)$
- Eliminate beams with very low Q
- Down select beams to optimize spatial distribution
- Distribute beams to on MPDV channels to:
  - Maximize jump off time difference in group of 4 ITU s
  - Separate beams that are closely spaced to unique detectors.
  - Group beams with similar Q values on same detector to reduce dynamic range compression.

Design Requirements for Optical Probe

- Minimize back reflection from mask-fiber interface
- Maximize number of fibers coupled to lens system to eliminate need for masks with unique designs
  - MPDV Gen 2 = 128 beams
  - MPDV Gen 3 = 256 beams
  - With spares ~ 500 beams

Future Development: New Lens

- Present lens uses index matching fluid between fibers and first lens surface
  - Matched for visible, but MPDV works at 1550 nm
  - Can dry out, temperature effects

  $\Rightarrow$Significant reflected power from lens >> surface.
- Plan is to develop means to weld glass fibers directly to first lens surface.
  - Negligible reflected power.
  - Stable
  - Cheap

End Cab Technology Sounds Promising

- **End cap technology**. This technology allows the fusing of a single mode or multimode fiber to a larger, coreless fiber, thus allowing the expansion of the beam (or spot size) to be scaled up for higher power applications. A typical application might be to fuse a 10 um multi-mode fiber to a 1 or 2 mm coreless fiber. By controlling the length of the coreless fiber (end cap), the divergent beam is still reflected internally (TIR) but can have a larger spot size at the end cap's exit aperture. By AR coating the end cap aperture, good transmission efficiency can occur and be available for downstream experiments.
- An offshoot of this technology could be the fabrication of a sensing array of many fibers fused to a common optical substrate (lens or flat substrate at a critical focal plane) for sensing applications.

Timbercon Products Used in Other Diagnostics

- Other Diagnostics Used on Hydrotest
  - TOAD – Standard, Jump Off PDV, Sensitive
    - 32 channels (4 racks, 8 channels each)
    - 8 channels (1 mini rack, portable)
    - 8 channels (portable, 4 channels per chassis)
  - CFBG
    - Classic – 20 channels
    - Time Domain – 14 channels